

CATCH UP GROWTH AND ITS DETERMINANTS IN LOW BIRTH WEIGHT BABIES: A STUDY USING Z SCORES

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ABSTRACT

Two hundred and forty seven low birthweight (LBW) survivors of our Neonatal Intensive Care Unit and 164 normal birthweight controls were followed up longitudinally from birth to 4 years and their growth trends (weight, height, head circumference) were expressed as mean Z scores in 500 g birthweight categories. Whereas LBW's demonstrated rapid growth in the first 6 months of life, followed by generally parallel trends with some tendency to rise, controls showed distinct growth faltering especially after one year. Only 30.8% of LBW's (and 49% of controls) were within the designated catch up levels for weight by age 4 years. The corresponding number for catch up of height and head circumference in LBW's was 22.8% and 26.5%, respectively. On multiple regression analysis, the most important determinants of catch up (at 4 years) in LBW's were weight at 1 year ($\beta = 0.51$), height at 1 year ($\beta = 0.31$) and mother's weight ($\beta = 0.04$).

Thus, Z scores enabled the demonstration of changing growth trends, simultaneous comparisons with local controls and international standards and comparison within indices. Growth charts incorporating Z score should be made available in a simplified manner for use in the community.

Keywords: *Catch up growth, Determinants, Low birthweight, Z scores.*

Satisfactory catch up growth is considered as one of the most important yardsticks of judging the quality of survival of small, preterm and low birth weight (LBW) babies(1,2). Difficulties in studying longitudinal growth include definition of catch up, finding suitable standards and controls and interpreting changing growth trends. It is generally agreed that growth monitoring should be done by international standards(3). However, there are difficulties in interpreting growth on standard centile, 'road to health' charts(4,5) as many of our LBW babies fall below the third centile and hence cannot be further categorized. Comparisons amongst various indices such as weight, height and head growth at various ages in longitudinal studies becomes particularly difficult. In view of these problems, analysis of growth with Z scores (SD scores) appears especially promising.

As catch up growth is considered as a measure of favourable outcome, identification of its determinants assumes great importance. Of special importance is prediction of factors of interventional value at birth. This study analyses catch up growth and its determinants (using Z scores) in a group of LBW survivors of our Neonatal Intensive Care Unit (NICU), followed up longitudinally at our High Risk Clinic from birth to 4 years.

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Subjects and Methods

Study Population

Three hundred and seven consecutive LBW survivors of our NICU (birthweight <2.5 kg) born between October, 1987 and April, 1989 were enrolled for this study. Thirty one babies died since discharge, 52 were lost to follow up, 10 did not agree to participate and 8 were excluded because of congenital abnormalities. The remaining 247 LBWs were regularly followed up in our High Risk Clinic, and their anthropometry was measured at predetermined appointments given at ages of 40 ± 1 week gestation, 6 ± 0.25 months, 12 ± 0.5 months and yearly ± 1 month thereafter. Defaulters were visited and measured at home by our medical social workers. A group of 200 normal babies weighing ≥ 2.5 kg, born at our Hospital during the same time period was selected randomly from a total of 500 births and similarly enrolled and followed up as 'Controls'. There were no deaths in this group, 21 were lost to follow up and 15 refused to participate.

Longitudinal Follow up

Anthropometric measurements were recorded within 24 hours of birth and weight for gestational age was calculated(6). Neonatal risks and morbidity were noted. During the High Risk Clinic appointments, weight was measured on an electronic weighing scale (Atco) with accuracy ± 10 g; length upto age 2 years was measured by an infantometer and beyond 2 years on a stadiometer (Microtoise, CMS instruments); and head circumference was measured by a non-stretchable tape. Three readings were made for each measurement and averaged for analysis. Weights and heights of both parents were also recorded. Socio-economic status (incorporating occu-

pation, education and income) was assessed using the Kuppaswamy score(7). Morbidity was assessed from parent-maintained records of minor and major illnesses, clinic visits and hospital admissions. Feeding pattern in the first year of life was recorded.

Z scores

Z score (also called SD scores) can be calculated using the formula,

Z score =

$$\frac{\text{Actual measurement} - \text{Median reference value}}{\text{SD value of reference}}$$

For this study, measurements of weight, height and head circumference at each age were transformed into Z scores using the Castlemead Growth Programme, which incorporates the LMS method(8), ensuring normal distribution of Z scores. Reference values were as per Tanner Whitehouse standards(4) for above 2 years and Gairdner Pearson standards(9) from 28 week gestation to 2 years. Mean Z scores calculated for various birthweight categories <1.5 kg, 1.5-2 kg, 2-2.5 kg, 2.5-3 kg and >3 kg were plotted longitudinally for all parameters.

Catch up Growth

Criterion for catch up was considered as actual value within 2 SD of median (*viz.*, Z score > -2).

Statistical Analysis

Determinants of catch up growth at 4 years were studied using the SPSS/PC+ software. Anthropometric parameters, neonatal risks, socio-economic factors, and morbidity and feeding in first year of life were correlated with 4 year weight. The significant correlates were then analyzed by multiple linear regression. The most likely combination of birth variables to

predict catch up growth at 4 years was analysed using discriminant function analyses (Stepwise method, Wilks).

Results

Birthweight and gestational age-wise distribution of 247 LBW babies and 164 Control babies, followed up from birth to 4 years is shown in *Table I*. The male : female ratio of the LBW babies was 1 : 1.1. Amongst the LBW, 175/247 (70.8%) were preterm and 180 (72.9%) were small for gestational age (SGA).

Growth Patterns-Z scores

Z scores to demonstrate deviation from international standard(4) for weight, height and head circumference of LBW and Control babies from birth to 4 years is shown in *Fig. 1*. Different birthweight categories have been plotted separately. Z scores of all parameters show a wide scatter at birth and generally tend to converge with increasing age, but the trends for individual birthweight categories remain constant.

Z scores for weight: All categories of LBWs demonstrated rapid weight gain in the first six months, which was followed by flattening of the curves in latter half of infancy and early childhood. The curves though parallel, showed some catch up trend. However, the mean Z scores for all

LBW categories at 4 years have remained >2 SD below the international standard. It is to be noted that even the control babies have shown an unfavorable trend in their mean Z scores beyond age 6 months, although they remain within 2 SD of the standard at 4 years.

Z scores for height: As compared to the weight curves, the mean Z score height

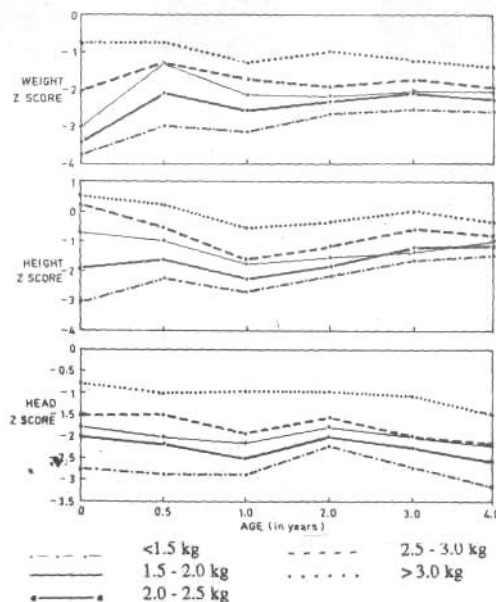


Fig. 1. Z scores for Weight, Height and Head circumference: (0-4 years), as per

TABLE I—Birthweight and Gestational-Age Wise Distribution of the Study Population (n=411)

Birthweight category (kg)	(n)	Gestational age (weeks)				
		<30	<30-32	32-34	34-36	>37
<1.5	89	6	15	37	23	8
1.5-2.0	112	-	7	34	42	29
2.0-2.5	63	-	-	-	1	62
2.5-3.0	104	-	-	-	-	104
>3.0	43	-	-	-	-	43

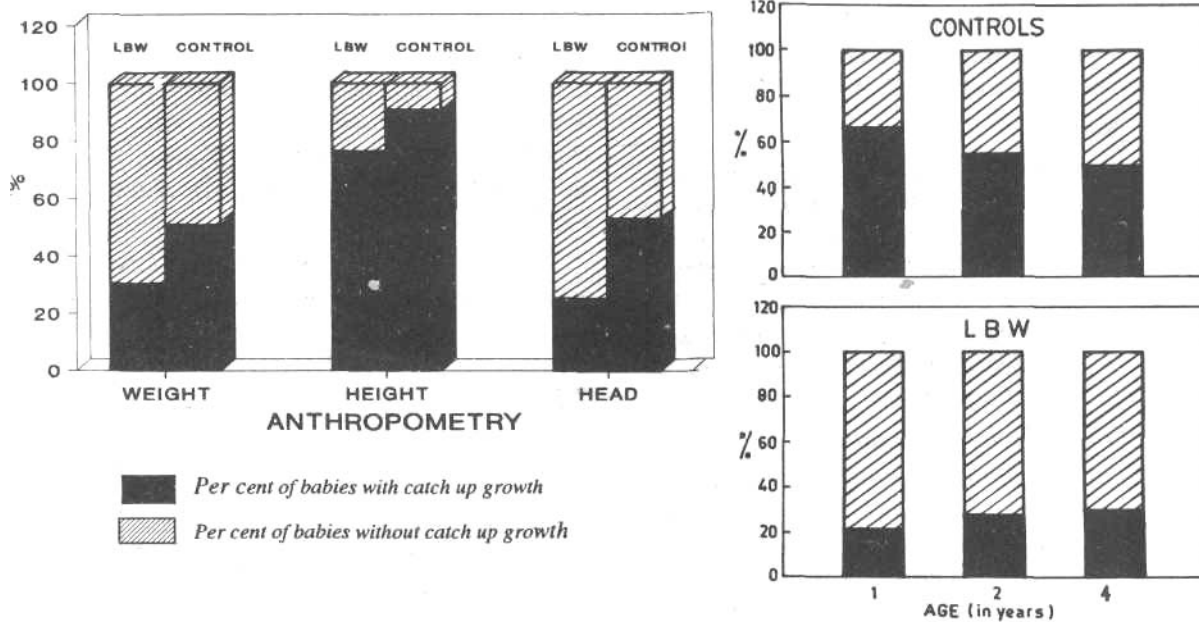


Fig. 2. Percentage of babies within 2 SD of reference median (catch up growth) for weight, height and head in controls and low birthweight babies at 4 years.

curves in LBWs have shown more favourable catch up trends so that all categories (including LBWs) have means within 2 SD of the standard at age 4 years.

Z scores for head circumference: In contrast to the catch up trends seen in LBWs for weight and height, the curves for mean Z scores for head circumference show an unfavourable trend especially beyond 2 years so that at 4 years all LBW categories are well below 2 SD of the standard. Significantly, this trend beyond 2 years is seen in control babies too.

Catch up Growth in LBWs (Fig. 2)

The number of LBW babies showing catch up growth (*i.e.*, Z score for weight within 2 SD of reference median) at 1, 2 and 4 years were 52 (20.2%), 71 (28.6%) and 76 (30.8%) respectively, the difference between 1 and 4 years being statistically significant ($p = 0.05$). Corresponding percent-

ages in the Controls at ages 1, 2 and 4 years were 65.8, 54.8 and 49, ($p = 0.06$) (Fig 3). However, inspite of catch up growth in LBWs and growth faltering in controls, the numbers with Z scores within 2 SD at 4 years was significantly higher in controls as compared to the LBWs ($p=0.0002$). Within the LBW group, the AGA babies showed better catch up (44.8%) as against SGAs (27.2%) ($p=0.01$).

The differences between the LBWs who caught up at 4 years and those who did not are shown in Table II. Babies who caught up had significantly higher socio-economic characteristics, higher parental anthropometry and lower birth-order. Babies who did not catch up had significantly higher number of SGAs ($p=0.0001$). Although neither birthweight nor Z score for weight at birth were significantly different in the two groups, Z scores for weight and

TABLE II—Differences (\bar{X}) Between LBW Babies, with and without Catch up Growth at Four Years

Parameter	LBWs with Catch up Growth (n = 76)	LBWs with no Catch up Growth (n = 171)	
Birthweight (kg)	1.74	1.65	NS
Gestational age (weeks)	35.9	35.8	NS
% small for gestation (SGA)	62	78	***
Ponderal index at birth	2.17	2.17	NS
Birth order	1.5	1.8	*
Numbers with neonatal risks (%)	46.8	40.5	NS
Z Scores at birth			
Weight	-2.8	-2.9	NS
Height	-1.8	-2.6	*
Head	-1.7	-2.25	NS
Z Scores at one year			
Weight	-1.9	-3.2	***
Length	-1.6	-2.8	***
Head	-2.3	-2.8	*
Mother's weight (kg)	51	45.9	***
Mother's height (cm)	154	151	***
Father's weight (kg)	64	56.5	***
Father's height (cm)	164.8	164.5	*
Duration of breast feeding (m)	10.3	12.7	NS
Diarrheal episodes			
0-6 mo	1.7	1.6	NS
6-12 mo	1.6	1.6	NS
Number in lower socio-economic class (Kuppuswamy score <15) (%)	29.1	49.4	**

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

height showed highly significant differences by age 1 year. There were no statistically significant differences in ponderal index at birth, neonatal risks, and diarrheal episodes in the first year of life. On multiple linear regression, the significant correlates of 4 year weight were weight Z score at 1 year ($P = 0.51$, $p = 0.005$), height Z score at 1

year ($P = 0.31$, $p = 0.01$) and mother's weight ($P = 0.04$, $p = 0.03$).

Discriminant Function Analyses

The best combination of factors at birth with the highest power of discrimination between LBW babies who catch up and those who do not, as analysed by discrimi-

TABLE III—Discriminating Variables at Birth for Prediction of Catch up Growth by 4 Years (Discriminant Function Analysis)

Discriminating factor	Discriminant function coefficient
Father's weight	0.56
Weight for gestation (AGA)	0.55
Mother's education score	0.45
Gestational age	0.38
Mother's height	0.34
Birth order	-0.26
Sex of the child (female)	-0.23
Mother's occupation score	0.22
Father's height	0.20
Father's education score	-0.18
Mother's age at birth	-0.18

Predictive value 76.47%.

Discriminant function is shown in *Table III*. Besides anthropometry and socioeconomic factors, the other characteristics of predictive value for catch up growth identified were gestational age, weight for gestation, sex, birth-order and mother's age at birth, (predictive value 76.5%).

Discussion

Anthropometric indices within 2 SD of the international reference medians have been variously accepted as a reasonable criterion to define catch up growth(1,10). By 4 years, only 30.8% of our LBW babies were within this range for weight and 22.4% for height. However, this has to be viewed against the growth patterns of our normal control babies (birthweight ≥ 2.5 kg), whose mean Z scores for weight and height were well within 2 SD at birth, but fell succes-

sively so that only 49% could be considered as within the designated 'catch up' values at 4 years (*Figs. 1 & 2*). Such growth faltering of normal Indian children beyond the first year of life, has been observed all over our country(11-13).

The most favorable trends in the Z scores for weight and height of our LBWs were seen in the first year of life, followed by generally parallel trends with a tendency to rise towards the median. Although lower birthweight categories demonstrated a proportionately greater gain, they still remained shorter and lighter than the higher birthweight categories at 4 years.

Analysis by Z scores was particularly useful to demonstrate these trends in catch up growth of our LBW babies. Comparisons with local controls and international standards as well as within indices (weight, height and head) was possible simultaneously (*Fig. 1*). Because Z scores are age adjusted, groups of children at different ages can be compared(14). Although many of our small LBWs fell well below the third centile of international standard, their further categorization in terms such as -1Z, -2Z, -3Z and so on could be done precisely. Growth faltering and catch up could be easily quantified by calculating a change in Z score. A WHO working group has recommended the use of Z scores for growth monitoring for public health and research purposes(15). But we, amongst others find it extremely useful for clinical purposes for monitoring individual patients too(16,17). It has, in fact been pointed out that Z scores could be easily incorporated in the popular 'road to health' charts thereby widening its scope even to health workers in the community(16).

Software programme for calculation for

Z scores are now available, failing which the formula described (see methods) can be easily used(18). NCHS standards(5), however, do not have corresponding intrauterine or preterm growth standards, and we therefore used Gairdner Pearson (28 weeks GA to 2 years) and Tanner Whitehouse standards (from 2 years onwards). This emphasizes the pressing need for a continuous scale to monitor preterm babies from their birth into childhood and adolescence.

An interesting observation was the observed faltering in head growth of both LBWs and controls as demonstrated by progressively lower Z scores, especially after the age of 2 years (*Fig. 1.*). This is in contrast to other studies especially from developed countries, which suggest that head circumference is the first parameter to catch up(19,21). Further correlations of faltering head growth with IQ tests as also the possibility of ethnic differences need to be evaluated(22).

Besides the other well-known socio-economic factors(1,23,24), other determinants of catch up emphasized in our study by discriminant function analyses were parental anthropometry, mother's education, mother's age at delivery and birth-order. This study once again confirms the better catch up of AGA babies as compared to SGAs(20,25). But of all the determinants analysed by us (multiple regression) weight at the age 1 year was most important, even more so than birthweight. This suggests that aggressive nutritional and growth monitoring throughout infancy is all important in improving eventual outcome. Establishing and improving specialised highrisk services can, therefore, be considered of interventional value in improving catch up of LBW infants(26). Interesting implications have also been made of poor growth in

the first year of life in increasing the risk of developing adult diseases such as diabetes and hypertension(27,28).

In conclusion, Z scores proved to be an extremely useful technique in longitudinal growth monitoring. Less than a third of LBW babies catch up by the age of 4 years. The most important determinant of catch up appears to be growth in the first year of life, emphasizing the need for specialized nutritional monitoring and interventions throughout infancy.

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